Art Gallery Problems with Distance Constraints Using Omnidirectional Cameras

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In recent years, a security camera is necessary and indispensable for security in a building. A big city has many skyscrapers and huge stations and room's layout is becoming complex. So, a number of security cameras are needed to observe them. Therefore, if the inside of a building can be observed using minimum number of cameras, we can reduce time and cost for maintenace. As the result, it is very important to decrease the number of the security cameras and find efficient arrangement.

In this research, we use an omnidirectional camera as the security camera. Then, we want to obtain the minimum number of security cameras needed to observe the inside of a building. Omnidirectional camera can take a picture of a scenery with 360 degrees at one shot. Omnidirectional camera has a character that the resolution of an image remarkably decreases as the distance is longer from an installation position. In fact, shooting's round has a limit. Omnidirectional camera can observe the entire environment by a small number of cameras, but it is difficult for us to use an omnidirectional camera for security reason, because it has different structure and characteristic from a usual camera. Therefore, it is very important to consider the problem of oberving a building using the minimum number of omnidirectional cameras.

Moreover, by using the omnidirectional camera, we can consider a more realistic version of an art gallery problem. The art gallery problem is a problem of finding a minimum number of guard members to observe the interior of a polygon P which is composed of n edges. The art gallery problem assumes that the guard member have a view of 360 degrees and have infinite eyesight. This assumption is impossible when you post a usual guard member and usual security camera. However, we can realize such a view for a guard menbers in the art gallery problem by using the omnidirectional camera. Therefore, we can assume guard member's view of 360 degrees. Moreover, we considered a general polygon in the art gallery problem, but a layout of a room is often given by an orthogonal polygon in an actual museum and a building. Therefore, we make more realistic asumption by making best use of the characteristic of omnidirectional camera in this research. We design best arrangement in which the number of the cameras is minimized to observe a usual building. We consider the problem as an optimization problem in computational geometry. The problem that a resolution is decreased as distance gets large is formulated using distance constraint. We also assume that an art gallery is composed of orthogonal polygons.

It is also useful to use omnidirectional cameras when we compose walk-through in a building. Walk-through is to synthesize an image from some pictures which is seen in an actual walk in a virtual space. In order to synthesize a walk-through image from a collection of pictures which were taken by a usual camera, we need information on where and which direction we look. Moreover, you should decide a route for walk-through and cannot change it later. If you want to compose a walk-through which you can stroll in a building, you need to take a huge number of pictures. For example, it is assumed that you want to get an image that you can see in all degrees. Then, it is assumed that viewing angular range of a usual camera is 120 degrees, and hence you should take pictures at least three times if you want to the 360 degrees image. When taking a picture, it is necessary to manage the information on place and direction of each photograph. And you should do these operations many times.

However, directional information becomes unnecessary by using omnidirectional cameras, because a view of an omnidirectional camera is 360

degrees. Therefore, you can freely change a route of walk-through. Moreover, the number of cameras can be greatly reduced, because you can synthesize an omnidirectional image in a place in which any picture has not been taken picture from some omnidirectional images obtained by taking photographs in many places.

In the thesis, we started from a mathematical formulation of the problem. The problem is originally defined in three dimensions, but it is enough to consider it in the plane of two dimensions when you deal with a museum, etc.

In addition, we limited ourselves to orthogonal polygons, because in many museums walls are orthogonal. Omnidirectional camera has the advantage that it is possible to take a picture in all directions, but it can't take a picture just below itself and far from it. This restriction is modeled by using an annulus. In a word, this problem is to minimize the number of annuli necessary to cover the entire wall of a given orthogonal polygon. We cannot find a accurate answer to this problem in polynomial time, but we show that it is able to solve it in polynomial time if we make an appropriate hypothesis on the calculation precision.